THE RELATION OF TRAUMA TO DIABETES*

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CERTAIN FUNDAMENTAL FACTS are herewith recorded, essential for a proper understanding of diabetes, and following these are various concepts which will serve as a summary of the relation of trauma to the disease.

FUNDAMENTAL FACTS CONCERNING DIABETES

1. Diabetes is an hereditary disease, characterized by an increase of sugar in the blood and the excretion of sugar in the urine; it is dependent upon the loss or decrease of the insulin secreted by the islands of Langerhans of the pancreas and is functionally interrelated with other endocrine glands, particularly the pituitary but also the adrenal, thyroid, and the liver.

2. Proof of the diagnosis of diabetes is all important. The lack of accurate, diagnostic tests in the past and the failure to distinguish between glycosuria and the disease (diabetes) renders valueless most of the older literature.

3. Diabetes is universal. It ranks eighth as a cause of death in the United States, and approximately one individual in 165 of the total population has the disease. No age, sex, race or social status is immune. Its incidence is increasing and presumably will continue to grow until the average age at death of the population exceeds the decade 44–55 years, in which it is most apt to begin. This makes the date of onset of the disease in relation to the time of the trauma a crucial factor. This is especially true if influences favoring the development of diabetes already exist. The onset of diabetes is usually indefinite, but it may be sudden and in the span of 24 hours, and was so classified by me in 1.3 per cent of one series of 7000 of my cases.

4. Legal proceedings, based upon trauma, during the course of diabetes either should be avoided or entered upon after unusual deliberation by diabetics. A diabetic may go to court and win his suit, but this discourages employers from hiring or even keeping in their employ other diabetics and puts off the day when the diabetic can enter government service or secure

* The author, with his associates, has written a more detailed discussion of Trauma and Diabetes in the volume Trauma and Disease, Brahdy and Kahn, 2nd Ed., Lea & Febiger, Philadelphia, 1941, pp. 536–589; also in The Treatment of Diabetes Mellitus, Lea & Febiger, Philadelphia, 1940, 7th Ed., pp. 76–87. In each of the foregoing articles references to the literature and citations of cases are numerous, but in this article I have tried to approach the subject from a somewhat different and more confident point of view because of the 22,258 diabetic cases having consulted my associates and me and, also, because recent advances in diabetic knowledge have confirmed many earlier suppositions. In general, the literature cited here is in addition to the bibliography of 83 or more references in the most recent of the above publications.

insurance. There are about 800,000 diabetics now living in the United States and in a peculiar sense each one is his "brother's keeper."

CONCEPTS CONCERNING TRAUMA AND DIABETES

1. The thesis that trauma *de novo* can cause diabetes has steadily lost support with the expanding knowledge of the nature of the disease.

2. But evidence has accumulated to show that trauma indirectly can activate, or accelerate the appearance of a latent diabetes in the hereditarily predisposed, particularly if accompanied by infection, reduced muscular exercise, gain in weight or overeating.

3. Trauma in the course of diabetes has grown in importance, because the duration of the disease has trebled, thus lengthening the period of exposure. Moreover, the danger of exposure to trauma is intensified each successive year a diabetic lives, because time is provided for the disabling complications of the disease to appear and the physical infirmities of the normally aging process to advance.

The tissues of a diabetic are more vulnerable than those of a non-diabetic.

4. Trauma may make the diabetes more severe, but this effect is not necessarily permanent.

5. Emotional, nervous, so-called neurogenic diabetes, as von Noorden well said, was put "into the grave" by the Great War, and there it is likely to remain unless exhumed during the present conflict.

6. To prove that trauma is the cause of diabetes in any individual case evidence must be at hand to show (a) that the disease did not exist before the trauma; (b) that the trauma was severe, injuring the pancreas; (c) that the symptoms and signs of the disease developed within a reasonable period following the trauma, the etiologic importance of the trauma waning with the prolongation of the interval; and (d) that the symptoms and signs of diabetes were not transitory but permanent.

7. This question of trauma as the cause of diabetes should be kept absolutely distinct from the question of compensation of an individual who is found to have diabetes following an accident. Too often, especially in foreign publications (Lommel, Troëll) the two are confused, and for social and governmental insurance reasons the court sitting in judgment on a case may vote to give the insured the benefit of a doubt which has no factual basis. Many European countries are saturated with social accident insurance, and if a citizen is not actually in the employ of the government, at least he expects a liberal interpretation of social or insurance benefits.

THE DISEASE DIABETES

1. *Diagnosis.*—The diagnosis of diabetes depends upon the demonstration not only of glucose in the urine (glycosuria), but also of a per cent of glucose in the blood (glycemia) of 130 mg., or above, when the subject has been without food for five or more hours or of 170 mg. (hyperglycemia),

or more, after intake of food. Insurance companies are suspicious of 120 mg. per cent fasting, and some clinicians raise the boundary line after food to 180 mg. per cent. Fifteen (14.8) per cent of all cases consulting me during the period 1897 to 1935 for a possible diabetes proved on investigation not to be diabetic. All but 32 of these 1946 cases were traced, and the diagnosis, in the course of years, was subsequently changed to diabetes, usually mild in character, in 193, but only in approximately a third of this number was it altered if the diagnosis was originally based on glucose tolerance tests. Other sugars, levulose, lactose, and pentose are occasionally found in the urine, but they have no connection with true diabetes. Glycosuria (non-diabetic), levulosuria, lactosuria and pentosuria are harmless states. The common tests for glucose in the urine are reliable and seldom subject to error, but this does not hold true for tests of the blood sugar which are more complicated and to be diagnostic must be carried out with special precautions regarding technic and reagents. The diet and the physical status of the subject at the time of the examination are of prime importance, else the reliability of the diagnosis is open to question.

Proof of the diagnosis of diabetes is all-important. Accurately planned and well-meaning conclusions concerning trauma and diabetes in the past today fall flat because the early authors did not have the facilities to distinguish between glycosuria and diabetes. Konjetzny and Weiland's conclusions, in 1915, upon glycosuria, diabetes and fractures, although still often quoted, are invalidated by the modern studies of Timpe, supported by tests of the blood sugar.

This very month a priest, Case No. 22290, told me, in applying for a Chaplaincy, he passed the Selective Service, including an examination of the urine, but two weeks later diabetes was discovered because the test was performed soon instead of long after a meal. Case No. 2063, with diabetes of 23 years standing, onset at 14 years of age, wrote me he also passed his entire physical examination including urine test, but was finally disbarred when he revealed his diabetes. He died suddenly in December, 1942, presumably of coronary thrombosis. The insurance policy which he obtained one year before was obviously cancelled.

2. *Did Diabetes Precede the Trauma?* Whenever the question of trauma as the cause of diabetes or as an incident in the course of diabetes arises, one should establish whether diabetes existed before the accident. For this purpose a rigorous search for symptoms and signs of the disease should be made as well as for the existence of factors predisposing to its development so that the date of onset can be determined with reasonable accuracy. This is not the place to discuss the symptoms and signs of diabetes, which are to be found in text books of medicine or in the monographs of Joslin, Root, White and Marble, and of Wilder, but some of the statistical data and influences provocative of the disease deserve attention.

What are the chances of an individual in the United States already having

diabetes at the time of an accident? The National Health Survey computed the number of diabetics in this country, in 1938, as at least 660,000, but in my opinion for this year, 1943, it is nearer 800,000. Diabetes occurs at any age, but with increasing proportion as one grows older. The frequency is 1 in 2500 up to 15 years of age in either sex, and reaches 1 in 70 for males and 1 in 45 for females at 65 years and above. Among Jews from early middle life on the incidence is higher, perhaps twice as great, being highest of all among Jewish women between the ages of 55 and 64, the proportion of deaths from diabetes to total deaths among Jews in New York City, in 1933, being 11.5 per cent. The draft has stimulated the finding of new cases not alone in the young but at all ages. In 1900 diabetes was 27th as a cause of death; in 1938, it was ninth, but in 1941 it advanced to eighth place. Diabetics are living longer and longer. Tabulations made by the Statistical Department of the Metropolitan Life Isurance Company, based on my own fatal cases, show that the duration of life of the average diabetic advanced from 4.9 years between 1898–1914 to 14.3 years between 1940–1942. The expectancy of life for a diabetic, also computed for my series, is about two-thirds that of the population as a whole for comparable age-groups.

A positive heredity also increases the chances of the individual having diabetes. Pincus and White conclude from their studies that at least 25 per cent of the population carry the hereditary gene for diabetes and are, therefore, predisposed to the disease. Heredity is greatest in identical twins, reaching 70 per cent; in cases with onset in childhood and living 20 or more years it is 62 per cent, and for 1800 diabetics on my service at the George F. Baker Clinic at the New England Deaconess Hospital in 1941 was 40 per cent.

A diabetic heredity makes an individual susceptible to the disease, but of all factors predisposing to its development by far the most potent is obesity. It precedes the onset of diabetes in more than three-fourths of the cases, and from 40 years onward reaches a still higher per cent. Among 2000 of my own cases of diabetes, not one occurred who was more than 30 per cent underweight, and in Adams' series of 1000 cases at the Mayo Clinic, no patient developed the disease who was more than 20 per cent underweight.

The type of onset of diabetes is of great significance no matter whether it is indefinite in 85 per cent of the cases, or sudden, within the space of 24 hours, in a trifle over one per cent, as already mentioned. Whereas the slow, unobtrusive onset presents many a puzzling problem before an approximately correct date can be fixed, the cases of sudden onset offer the best evidence for a *post hoc propter hoc* argument. Eight thousand (one per cent of 800,000) or more cases with a sudden start of their disease are now available in the United States. What opportunities they afford for traumatic, diabetic exploitation! This special group represents the *élite* corps from which recruits for the traumatic etiology of diabetes should be most easily obtained, but that I have recognized none with a traumatic basis among the

more than 200 of this class I have personally studied, is of some import. One of the best examples in my own clientele of the sudden beginning of diabetes is the following:

Case No. 13,332, who was in perfect health, so far as he or his family knew, on December 24, 1934. That night, this 14-year-old Jewish boy, with diabetic heredity, slept without rising from bed. On Christmas day there was no especial excitement or careless eating, yet at night he rose six times, and 17 days later, when I first saw him, the urine contained eight per cent sugar. He was doing well in September, 1942, but the diabetes persists.

There was no accident here to cause diabetes. There was no heredity known at the time, although later it was learned his mother's cousin had diabetes. Suppose your automobile injured this lad while coasting on Christmas Day, or that for some reason you had severely reprimanded him and he had undergone an emotional reaction. I feel confident that abroad, if the case came into court, the acute onset of his diabetes would be put in evidence against you, and for social and insurance reasons he would have secured favorable consideration unless in a country where he would be debarred by race. In such a situation attention should be focused on the overwhelming number of similarly acute cases, which spring into being without any reason whatsoever to suspect physical or psychologic trauma.

All these considerations, therefore, show how essential it is to investigate the background of any case of trauma in which diabetes may be a factor.

TRAUMA RARELY A DIRECT CAUSE OF DIABETES

Less and less credence has been given to the direct causation of diabetes by trauma since 1889, when it was demonstrated that its etiology and pathology centered in the pancreas. Total removal of the pancreas in a dog invariably brings on the disease, but that organ has such a high factor of safety that it fails to appear if more than one-fifth of the gland remains. This anatomic fact, in itself, shows how futile the attempt must be to connect bodily trauma with diabetes. Moreover, the pancreas lies in the depths of the abdominal cavity, with the abdominal wall, peritoneum and stomach in front of it, is partly overhung by the liver and in close touch with the spleen, and posteriorly is protected by the backbone. It is hardly conceivable that four-fifths of it could be destroyed and yet allow life to go on. The discovery that insulin, the hormone which controls the disease, is manufactured only in the *beta* cells of the islands of Langerhans scattered through the pancreas and weighing only one-twentieth that of the entire gland, made the evidence of the unity of diabetes complete.

Subsequently, the close connection of the pituitary gland, situated in its bony case in the center of the skull, with diabetes was recognized, and, later, it was found that actual diabetes could be brought on by injections of an extract of its anterior portion. At first, this reawakened the thought that the nervous system after all was independently involved in the causation of

diabetes and that diabetes was perhaps influenced both by functional as well as organic insults to the brain. Such suppositions, however, were soon dispelled when investigation disclosed that the diabetogenic action of the anterior pituitary extract lay in its power to destroy the cells of the pancreas which produce the insulin and thus caused the disease. Thereby the unity of diabetes and its localization in the pancreas was again demonstrated. (Very recently the influence of the suprarenal gland upon carbohydrate metabolism has received fresh emphasis.) An injection of the extract of its cortex will accentuate diabetes and, conversely, removal of the cortex will lessen its severity. In rats, Ingle has produced a diabetic state by injection of massive doses of cortical extract, but this does not persist when the injections are interrupted. Evidence regarding changes in the pancreas is as yet not available. I know of no instance in a human being in which disease or injury of the adrenal gland has brought on diabetes.

Today, to prove that trauma causes diabetes one must show that the pancreas is gravely injured, in fact, at least four-fifths destroyed, probably nine-tenths, or that the trauma has so acted upon the anterior pituitary gland as to cause it to discharge an excess of extract which, in turn, can destroy the insulin-producing cells of the pancreas. These are the two methods, but examples of the same are almost unknown in humans. For the pancreas, to my knowledge, there exist only the cases of Wells, Stern, and the two of Grafe, which have gained general recognition as proving injury to the pancreas led to diabetes, and not one of these cases is above criticism. As for trauma to the pituitary leading eventually to diabetes, the evidence is still less convincing, and Rathery's recent description of an acromegalic with a complicated head injury, is only remotely conceivable as an example of stimulation of pituitary remnants to excessive secretion. As a matter of fact, he did not attribute the diabetes in this acromegalic, following removal of an eosinophilic adenoma of the pituitary, to the pituitary itself, but rather to the injury of the neighboring hypothalamic region.

Grafe's case of trauma causing diabetes, in my opinion, is the most striking of any in the literature. A condensed report of it is herewith appended:

Grafe's Case.—A merchant, age 75, supposedly free from diabetes, *en route* to a bath cure on account of gallstones, while driving at 50 miles an hour, put on his brakes sharply to avoid a motorcycle and hit a tree. His chest and abdomen were pressed against the steering wheel. No pain followed the accident and he resumed driving, but within three hours developed a gallstone attack. Nevertheless, he continued his journey the next day with a hired chauffeur but, the attack persisting, transferred to a train. Upon arrival at the Spa two days after the accident, he was somnolent, had an acetone breath, showed blood in vomitus and stools and had marked thirst. The glycosuria was 4.7 per cent, blood sugar over 500 mg. Upon entrance to Grafe's Clinic that same day the breath had an acetone odor, glycosuria 4.5 per cent, marked reactions for acetone and diacetic acid, blood sugar 556 mg., no vomiting. There was pallor, pulse good, hemoglobin 85 per cent, abdomen perfectly soft, and although no pain on pressure, cautious palpation revealed indistinctly a sausage-shaped tumor. Glycosuria and acidosis were controlled during the night with 160 units of insulin but

although conscious in the morning with blood sugar 84 mg., he failed rapidly and died at 8:30 A.M. Autopsy showed thrombosis of the splenic vein with pancreatic apoplexy, thrombosis of a branch of the portal vein, fat necrosis of the omentum and mesentery, diffuse peritonitis, and general congestion of the organs.

Grafe's case would appear to show that an injury to the pancreas could be a direct cause of diabetes. However, I have not met with such an instance among the 22258 patients consulting me on account of sugar in the urine. Although his case fulfills many of the criteria essential to explain the onset of diabetes as the result of an accident, nevertheless, its deficiencies are plain: First, diabetes was supposedly absent but not proved absent before the accident. The age of the patient, his sedentary occupation, the association with gallstones, which so often are present in the obese, along with diabetes, raise grave doubts as to the development of diabetes *de novo*. Criticisms of this nature can be raised with nearly every case of so-called traumatic diabetes, but of course are not wholly valid. The case, however, is a model one in these respects because: First, an attempt was made to rule out the presence of diabetes before the accident; second, the accident was of an overwhelming nature to the abdominal region; third, the diabetes followed closely upon it; and, fourth, the autopsy disclosed an extreme injury to the entire pancreas. At the same time, it emphasizes how extraordinarily rare such an incident could occur and the patient live long enough to have diabetes.

Injury to the Pancreas without External Bodily Trauma.—The pancreas being the center around which diabetes revolves, any avenue of attack upon that organ, even indirectly due to trauma, must be considered. There are various possibilities.

Pancreatitis: This is not an uncommon condition. When an inflammation attacks the gland it is generally severe, extensive and serious, and usually results in death. Strange to say, pancreatitis is seldom accompanied by diabetes. I have had one case among my 22,258 diabetics in which it appeared to be of causal significance. Umber, in his series of 7,000 diabetics, reports one instance, and although others less well authenticated have been described, the total number of cases either in a series of diabetics or in a series of cases of pancreatitis is surprisingly small. Nevertheless, if trauma could be shown to produce pancreatitis there would be some ground for considering it as leading to diabetes. The gallbladder is so near the pancreas that the possibility of infections spreading from it into the pancreas and causing diabetes appealed to me for many years. Statistical evidence based upon my own cases and upon studies of the Metropolitan Life Insurance Company forced me to give up this idea.

Hemochromatosis is a disorder of metabolism which leads to a deposition of iron pigment in various cells of the body. Usually it is accompanied by diabetes obviously brought about by deposition of the pigment in the cells of the islands of Langerhans of the pancreas which ultimately leads to their destruction. It was suggested by Mallory that the ingestion of copper was

the cause, but as yet that explanation has not been generally accepted. Conceivably, exposure to poisoning by copper or to anything which would bring about hemochromatosis might be adduced as trauma and thereby an indirect cause of diabetes.

Cancer involves the pancreas and exceptionally is accompanied by diabetes. It is not always easy to say which disease begins first, but there are a few instances in which the author reporting the case considered that the onset of cancer was first and diabetes followed. But if there is evidence that trauma can cause cancer of the pancreas, I do not know of it.

Infections: It is true that diabetes is occasionally discovered at the time of an infection, but infections are so frequent and the detection of diabetes so rare during them that statistical evidence pointing to cause and effect is slight. Priscilla White found in our diabetic children that the incidence of infections in the preceding history was distinctly less than the incidence of infections in children generally. Lande, writing from Umber's clinic, came to the same conclusion.

An infection makes an existing diabetes more severe is a statement commonly acecpted, but there is, likewise, agreement that following the subsidence of the infection the type of the disease returns to its former level. Prolonged infection, whether due to the pyrogenic group of bacteria or to the tubercle bacillus, finally ceases to aggravate the diabetes, as my colleague, H. F. Root, has shown. The fundamental principle that an infection makes the diabetes worse is so generally accepted that it need not be further elaborated here.

Injuries to the Nervous System: Both psychical trauma and organic trauma to the nervous system have often been adduced as a cause of diabetes, but both were dissipated by the World War. Labbé, in France, did not consider trauma an etiologic factor in a single one of 600 diabetic soldiers. I was medical consultant at Mesves hospital centre, through which passed 38,765 soldiers, and there were but three cases of diabetes, two of whom I saw, and there was not the slightest indication that they were related to psychic or organic trauma. "Yet the World War presented an ideal opportunity for the physical and psychic traumatic origin of diabetes both in the combatants and noncombatants and that the disease did not materialize is most significant. The fear of an operation or of the pain incident to child-bearing and the extraction of teeth do not bring on diabetes, neither do we know, nor have we read in the literature, of a surgeon who postponed an operation for fear that the trauma incident to it would cause diabetes."

I know of no instance in which diabetes has been caused by accidents in the course of college athletics, particularly football. Dr. Arlie Bock, Department of Hygiene of Harvard University, wrote me in 1940: "As far as I can determine, no case of diabetes following trauma has occurred among athletes at Harvard. We have had many types of injury, but no known injury of the pancreas, and whether such trauma might result in diabetes I do not

know. You know there has been close medical supervision of athletes at Harvard for at least 25 years." A medical observer of pugilistic contests for 25 years assured me that he had never come across a single person who ever had any symptoms or any knowledge that he had diabetes or had been suffering from diabetes.

Dr. Harvey Cushing reported no instance of diabetes following the development of a tumor in the brain, save those in which diabetes occurred in connection with acromegaly and basophilism, and two patients (out of over 200) with chromophobe adenoma. "What is very significant," according to Dr. Louise Eisenhardt, "is that in Dr. Cushing's own long experience in operating for tumors of the hypophysis or third ventricle he found that such operations did not result in even a transient glycosuria." Dr. Gilbert Horrax, now in charge of the Neurosurgical Department of the Lahey Clinic, formerly Dr. Cushing's associate, confirms what Dr. Eisenhardt has written. Dr. Donald Munro of the Boston City Hospital writes: "I can cite the fact that, in over 3000 craniocerebral injuries, I know of no case in which the trauma had produced either diabetes mellitus or glycosuria by the time the patients had left the hospital after treatment for their injuries." In Germany, Jacobi quotes Liniger as reporting 300 severe head injuries without the development of diabetes and cites Bürger and Poppelreuter to the effect that among several thousand brain injuries no case of definitely traumatic diabetes was observed.

Opinions Pro and Con Trauma as a Direct Cause of Diabetes.—Viggo Thomsen, in his monograph of 416 pages, concludes: "Theoretically, it must be admitted that diabetes can appear as a direct sequel to a pancreas trauma which gives rise to extensive destruction of the pancreas. Other physical traumata are unable to cause diabetes. A physical trauma may give rise to an exacerbation of existing diabetes, but the exacerbation manifesting itself immediately after the trauma is temporary only. Thus the assertion frequently set forth that a physical trauma is able to exacerbate a latent diabetes so that the disease, owing to the trauma, becomes manifest cannot be maintained."

He reaches the above conclusions after an historical, clinical and experimental review of the subject. His conclusions are based, first, upon a study of 144 surgical accident cases admitted to the Aarhus District Hospital, in Denmark, to 100 of whom he gave a glucose tolerance test within three days after the accident. Of the 50 showing disturbances of carbohydrate metabolism, and discharged, he followed the course of 47 for periods of 6 to 38 months. Second, he investigated the effect of the accident on 100 injured diabetics. Third, he compared the antecedent history of trauma in 457 diabetics and a similar number of nondiabetics. "The results of this examination indicate that there is scarcely any difference in the frequency of occurrence of diabetes in injured and noninjured persons of the same age and standard of life." Finally, fourth, he summarizes the details of 81 cases of reported alleged diabetes in the literature.

Lommel, however, is a recent writer who takes up the other side of the question and presents it forcibly, citing the authors who support his view. He argues against rigid dogmatism in so complicated a condition as the causation of diabetes. His theme is that it is not right to assert that because a given explanation *ought not to be* correct is a reason that it *cannot be* the explanation. He assumes the cause of diabetes to be unknown and that it probably comes from an interrelation of many circumstances. He points out the paucity of changes in the pancreas in diabetic children, but he overlooks here, to my mind, the transitory nature of hydropic degeneration when diabetes first appears and the slow development of hyaline changes in the islands in the young. As for heredity, he considers this disposition to diabetes well-nigh universal. He does not believe in a sharp distinction between glycosuria and diabetes and thus is in definite antagonism to men, such as von Noorden, with large clinical experience. To some extent he concedes psychic trauma can lead to diabetes, but to this conclusion I suspect he is evidently somewhat influenced by Strieck's experiment on injury to the hypothalamic area, which has not yet been confirmed. On the other hand he demands (1) that the subject must be proved to be not obviously sick before the accident; (2) that the trauma must be severe, either acting externally with force or exerting a sudden, powerful, psychic provocation; (3) that the glycosuria shall be lasting; and (4) appear in not too remote a period from the accident.

Lommel, in writing his article, has evidently not been in touch with recent experimental work outside of Germany, which has so greatly clarified the problem of the causation of diabetes, and indeed his ideas are also contrary to the prevailing view in Germany itself when he wrote.

Troëll, in Stockholm, in a carefully prepared article, reports ten cases in which glycosuria or diabetes was present with trauma, and even passed upon by the board of reparations. In only two of these was the trauma considered as a cause of the diabetes. The evidence by no means was as strong as in Grafe's case and, in one, followed an injury to the elbow, and the *post hoc propter hoc* argument was raised because the urine was said to be sugar-free the day before the accident. In two instances temporary glycosuria followed a pistol shot wound of the chest or a fracture of the internal malleolus, in a fifth, the later entrance of cancer into the situation led to compensation, in two, trauma delayed, and in two, did not delay healing, and in fact the diabetes was directly responsible *per se*. The tenth, was a case of long duration in which the injury was insignificant and pneumonia decisive. These cases are carefully reported and the circumstances of each are clearly discussed. Troëll, like Lommel, is unwilling to concede that trauma to the pancreas alone can cause diabetes. He believes, as Naunyn emphasized, peripheral injury elsewhere *via* paths of the sympathetic nervous system could be a factor in bringing on the diabetes disagreeing

absolutely with Thomsen. His views seem to me to be biased by Swedish social accident insurance.*

THE ACTIVATION OF LATENT DIABETES BY TRAUMA

The presence of (1) heredity makes an individual susceptible to diabetes, and when to this we add (2) an age in which the incidence of diabetes is high, (3) obesity, (4) reduced exercise, and (5) an infection, the stage is set for a latent diabetes to become manifest. Such a situation is not unusual, and one of the commonest examples is the individual who develops a carbuncle following an almost infinitesimal trauma. With the fulminating carbuncle, the diabetes previously unrecognized, although very likely existent, according to Naunyn, may become critically severe, requiring 100 or more units of insulin, and yet when recovery ensues insulin can be omitted and the diabetes again becomes so submerged that the patient can tolerate more than 200 grams of carbohydrate and, to the unwary, appear cured. But the diabetes is still there, latent, ready to come to the surface again on any provocation. One must extend the importance of trauma far beyond the case of the man with a carbuncle. Any injury to an hereditarily predisposed individual, provided in its train come prevention of customary exercise, exposure to overeating, and particularly if an infection is involved, one must agree, makes a latent diabetes liable to become active. It is by no means necessary that all these factors be present. Proper treatment can control such a diabetes, which is usually mild and may make it appear nonexistent, but the disease once established is really not cured. Space does not allow the presentation of cases, but such have been already published by me. It is the indirect effect of the accident rather than the direct trauma which causes the trouble.

TRAUMA IN THE COURSE OF DIABETES

Trauma is very common in the career of a diabetic. We have 1800 or more diabetics at the New England Deaconess Hospital annually, in ward

* In this connection, a patient is recalled who had been himself an insurance salesman. He maintained in court action, directed against an insurance company, that he had sustained an accidental injury to one toe by stubbing it against a chair on a public excursion boat in Boston Harbor. This injury he claimed had led to infection, and the injury had resulted in diabetes followed by angina pectoris. It happened that he had a peculiar insurance policy which provided for triple indemnity in the event of injury occurring accidentally on a public carrier. If it could have been maintained successfully that this accident had caused not only the injury to the toe, but *via* the sympathetic nervous system, also the diabetes and angina pectoris, under the terms of his contract the total indemnity would have been about $80,000. Actually, in this case the records showed that his diabetes had existed prior to the accident. If such an interpretation as the claimant urged had been accepted by the courts and a precedent thus established, it is easy to see that insurance premium rates would eventually be greatly increased either generally or specifically in patients where diabetes could be established from hereditary family history. Therefore, actually, the acceptance of such a point of view while probably immediately profitable to the one person involved would have social consequences for a large number of people, which would be most costly.

beds and private rooms. At various times, surveys have shown that 45 to 50 per cent of all our diabetic patients, under treatment at any one time in the hospital, came on account of an accident, but this statement is somewhat misleading. Such cases require a longer hospital stay and, therefore, appear proportionately more numerous than they actually are. It would be a fairer statement that one-quarter to one-third of all the patients in the Clinic in the course of a year represented the incidence of trauma. Accidents taking place in the hospital were found to occur relatively six times more frequently among the diabetics as among the nondiabetics. In statistics gathered from New York hospitals the incidence of operations upon the lower extremities in diabetic women was 150 times that in nondiabetic women. The diabetic is more susceptible to trauma than the nondiabetic, because his tissues are more vulnerable.

Purposely, in this discussion I will say little about those controversial features such as tissues of diabetics and the corresponding deficiency in glycogen. Such alterations cannot help affecting the soil, but it is difficult to measure the effect. In one instance we have the normal state and in the other an abnormal status, and that cannot be as advantageous. Then there are the abnormalities due to the products of acidosis; to excess of cholesterol; to an imbalance in the mineral constituents—all, very likely, are important in affecting the resistance of the part but not necessary to prove the diabetic more vulnerable to trauma, because there are so many other features in the diabetic which plainly influence the issue of the trauma for better or worse.

The degree of vulnerability varies with the age of the individual and his circulation, the nerve supply of the part, the severity of the diabetes, the duration of the disease, and its degree of control, not alone at the instant of the trauma, but from the day of onset of the diabetes.

Diabetics at present, based on mortality tables, are living about 14 years and approximately one-half die of arteriosclerosis in one or another of its various manifestations. Add to the developing arteriosclerosis in a diabetic the hardening of the arteries which comes to everyone as age advances, and his susceptibility to trauma increases. Arteriosclerosis implies deficient circulation, and circulation is all important in the healing of wounds. Step on the toes of a child or young adult and he forgets it in a few minutes, but the same blow on the foot of an old man may cause him to be confined to his bed for weeks, and, if a diabetic with poor circulation, he can lose his toe, his foot, his leg or even his life. The blow in one instance is on tissue with good circulation, in the other with poor circulation. On one side of the highway between Phoenix and Tucson the crops are flourishing, but on the other the land is barren and the irrigation canals, the circulation in the soil, show the reason why.

The normally functioning nerve supply of a tissue not only affects susceptibility to trauma, but the ability to heal the injured part. This is easily

overlooked. The wires are there, but they do not always transmit the messages or only a part of them. The diabetic may lose the sense of distinguishing between heat and cold and as with two of my patients the foot gets frost-bitten on Cape Cod or burned in Canada. His sense of pain is impaired and four of my patients have walked around at work all day and on removing their shoes at night found a tack which had evidently penetrated the sole of their foot hours before. My colleague, Howard F. Root, has collected 15 of our cases in which the ankle bones were actually destroyed and without the patients experiencing pain—a condition known as a neuropathic joint, akin to the Charcot joint of syphilis. I have seen a surgeon repeatedly open with strong scissors, in the ward before a group of visitors, nonnecrotic areas in diabetic feet for drainage or other reasons, making cuts one or two inches long without any anesthetic or any sign of discomfort on the face of the patient. It is seldom we do not have a patient with anesthetic feet in the hospital, and so vicarious is the absence of sensation that one foot may be anesthetic and the other not. I suspect that some of our patients who have gangrene originating from trivial exposures may have their lesions dependent upon lack of trophic nerve activity. Then there is the liability to accident because of loss of power due to the nonfunctioning of the motor fibers of the nerve. Common examples are toe-drop (peroneal paralysis), inability to rise from a chair (quadriceps paralysis) and double vision (external rectus), and, in rare instances, almost complete paralysis of the muscles of the entire body. Is it any wonder such people have accidents? The neuritis may affect the nerves of the intestines, resulting in an almost intractable diarrhea or those of the urinary bladder with distension and paralysis of that organ. In Walla Walla, Washington, just at the edge of the city, there are fields of luxuriantly growing onions and I was told the land was worth $1000 an acre, but across the way the property looked the same to me, but was uncultivated simply because a mineral was lacking in the soil. Some diabetics are lacking in an efficient nerve supply.

The severity of the diabetes affects the vulnerability of the diabetic. His disease may be so mild that it is almost impossible to distinguish between health and diabetes, and this status may last for 10–20 years if moderate discretion in living is observed. Contrast this type with that of the severe diabetic who with exposure to extra exertion, directly incident to trauma, can go into coma. The liver of a mild diabetic is good enough to allow him to take ether, but give it to a severe diabetic, uncontrolled for the time being, and he dies of acidosis, just as Case No. 729 did, who took ether for a dental extraction on Tuesday and died on the following Friday of diabetic coma in preinsulin days. The severe diabetic is the one who has the complications affecting the circulatory and nervous systems, complications of the eyes with all that goes with impairment or loss of sight, and even complications of the bones in part due to their decalcification. This is manifest even in young patients. A review by Eisele of our 73 children, onset

under 15 years of age, who have survived 20 or more years of diabetes, illustrates the seriousness and frequency of complications in the diabetic which make him a prey to accidents. Thirty per cent of those examined roentgenologically showed peripheral arteriosclerosis, 55 per cent moderate to advanced arteriosclerosis, and 70 per cent of the patients showing these changes had either a high blood pressure or albuminuria, or both, at an average age of 29 years.

An infection makes a diabetes worse. To that all agree. The instant an infection enters the picture of trauma a whole train of disastrous consequences is set loose. The infection not only makes the diabetes more severe, but it usually prevents exercise, a most desirable adjunct to diet and insulin in the triology of treatment, confines the patient to bed, with the possibility of contracting pneumonia, bed sores, and, with the old, to disarrangement of life-long habits of regulating the action of the bowels and urinary tract, which in the end may prove to be far more serious than the accident itself.

The duration of the disease counts. How can it help it? Before the discovery of insulin, up to 1914, my patients lived 4.9 years, and 1.8 per cent survived 20 years. Today, fortunately, the average duration has lengthened to 14.3 years, and 19.1 per cent survive 20 years, and eight per cent over 25 years. They cease to live because they are more vulnerable. Their life expectancy was two-thirds, and I hope in the next series studied will be three-fourths that of their nondiabetic confrères. Although not always measurable, yet with each added year of a diabetic's life there is some impairment in bodily function.

Finally, the degree of control of the disease counts too. Insulin has proved that for the average diabetic. Even before insulin was discovered adherence to the diet and good hygiene enabled many a moderately severe diabetic in the older age-groups to live. Between 1922 and 1929 gangrene caused 8.5 per cent of our 1448 deaths, but between 1937 and 1940 only 4.7 per cent of 929 deaths. The duration of the disease was 8.1 years in the former period but was 12.5 years in the latter, the average age at death being, respectively, about 63 and 67 years. Thus, better control of the disease despite its longer duration and the older age of the patients reduced the mortality from gangrene which in about half our cases was provoked by trauma. The same degree of trauma can play havoc with a poorly controlled diabetic which would be tolerated with comparatively little trouble by a diabetic living up to the rules. Most of the difficulties of the diabetic are of his own choosing.

TRAUMA IN CONNECTION WITH THE USE OF INSULIN

Within a very few months after the use of insulin in human beings instances of infection at the site of injection of insulin ceased to occur. Among 1838 admissions to the George F. Baker Clinic during 1941 there were but 8 who entered for abscesses due to the injection of insulin. When one considers that only this small number of incidents occurred among many million injections in patients both inside and outside the hospital, it is evi-

dent both the manufacturers and the patients use care. Needles broken in the skin during injection have never led to serious trouble in my experience, and such occurrences are even more rare than abscesses. A far more frequent, and infinitely more serious, opportunity for trauma is that incident to an insulin reaction. However, despite the thousands of insulin reactions occurring in the course of treatment of diabetics, I do not remember one resulting in a fracture. This is in marked contrast to the incidence of fractures when insulin is employed to produce convulsions in nondiabetic neurologic patients. I did observe one case in which death appeared to result from the patient, while unconscious, having regurgitated food which plugged the trachea. Still more serious are those cases in which an insulin reaction has been mistaken for diabetic coma and, in consequence, a dose of insulin has been given which resulted in death. Fortunately, such instances are few, in fact, I know of but nine among 15,000 or more of my patients who have had insulin administered. Four of these received additional insulin while in shock, one, undoubtedly, took a lethal dose of insulin with design, and the circumstances regarding the remainder were somewhat obscure. None of the cases were observed in Boston, and but five were seen in consultation.

In the preparation of this article I have been aided by too many friends to mention here, but I am especially indebted to Dr. Howard F. Root, my colleague of 24 years, who not only has given detailed help but agrees with me in the views expressed.

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